CANADA

DEPARTMENT OF MINES

HON. CHARLES STEWART, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER.

MINES BRANCH

JOHN McLEISH, DIRECTOR.

Investigations
of the
Mineral Resources Division
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Canadian bentonites for industrial purposes. It has been shown, however, that certain of the samples compare very favourably with the Wyoming bentonite that was employed as a standard in the investigation. Unfortunately, the deposits from which this good grade of material was taken, are all very thin, scarcely exceeding 12 inches, and consequently they can in most instances hardly be regarded as of economic importance.

Mr. A. E. Thompson, chemist in charge of the laboratory work being conducted on bentonite, states he has reason to believe that certain samples of what was at first regarded as inferior bentonite, owing to the apparent failure of the material to gelatinize readily on the first addition of water, show indications of improved behaviour on prolonged immersion, with agitation. It is possible, therefore, that certain deposits of workable dimensions, which were at first thought to carry only material of inferior grade, may yet prove to be of economic importance.

III

ALKALI DEPOSITS OF WESTERN CANADA 1920

L. H. Cole

Occurrence.—Natural occurrences of soluble mineral salts are known in the provinces of Manitoba, Saskatchewan, Alberta, and British Columbia, either in the form of bedded deposits, or as brines. Some are of considerable extent, and are probably of sufficient size to warrant commercial development.

The occurrences of these salts may be broadly classed under two types:—

(1) Solid salts and brines in undrained or partially drained basins;

(2) Brines of flowing streams or springs.

Type 1

Those of the first class are very numerous in the Prairie Provinces.

It is probable that the accumulation of salts is due to leaching out of the soluble salts in the prairie soils by surface waters, and their concentration and deposition in the undrained basins which are found in the glacial morainic covering of the western prairies.

These deposits are generally of a similar character, although the percentage of the different salts will vary in different localities. In many cases the name "alkali lake" has been appropriately applied to deposits of this nature, since in the early spring and often into late summer the deposits are covered with water. The water accumulating through the melting snow and rain is often a foot or two in depth, and carries a considerable quantity of the alkali salts in solution. Beneath this water one generally finds a solid bed of crystallized salts. In the late summer, especially when the season is a dry one, these so-called lakes become deposits of snow white alkali, which when seen from a distance resemble snow covered basins.

The deposits will vary in size from a few acres to many acres in extent, and in thickness from a few inches to possibly 15 feet. The salts are generally found interbedded or mixed with mud or peaty material, and in very few instances are the deposits in a pure enough form to be commercially marketable in their raw state. The mud beds also contain numerous crystals of the alkali salts.

Type 2

Brine streams or springs occur in many places, and may carry sufficient salts in solution to warrant their commercial exploitation for medicinal and other pur-

railway. No talc has been shipped from this property but the talc body has been exposed in several openings made for gold. The talc occurs as a band of green, massive steatite, enclosed in slates; the entire series being tilted into a vertical attitude and being much jointed and squeezed. Little of the talc comes out in the form of compact blocks of any size, the material breaking up into irregularly shaped pieces, with slickensided surfaces. As far as could be ascertained from an examination of the tunnel that crosses the talc body, the latter has a width of about 8 feet, and is bordered on both sides by about 25 feet of more or less talcose slate (soapstone). The talc grinds to a soft, grey-white powder, that should prove suitable for the paper, paint, rubber, and roofing trades. The property is well situated for working, lying close to, and higher than, the railroad tracks. The present operators are the B.C. Silica & Talc Company, Rogers Building, Vancouver, who mined only quartz during 1920.

A talc deposit on Wolf creek, Victoria mining division, Vancouver island, was visited and found to be working on a small scale. The property is situated 33 miles from Victoria, and about three-fourths of a mile from the track of the Canadian National railway. The deposit consists of a narrow band of grey-green talc schist, dipping about 60°. The talc zone is enclosed in slates, and the whole is considerably squeezed and crumpled. A tunnel has been carried 50 feet along the talc body, and is reported to show 18 feet of ore. The operator is W. G. Dickinson, 576 Dallas Road, Victoria, who has taken out about 300 tons of talc. This material was shipped to his grinding mill at Sydney, and ground for roofing purposes. Mr. Dickinson states that the quality of the talc has been favourably reported on by Pacific coast paper mills, and that contracts have been entered into to supply crude talc to American mills in Washington. The talc of this deposit is evidently an altered, coarse-grained schist, and contains an appreciable amount of dolomite; it grinds to a light grey powder. The deposit carries no massive talc, suitable for cutting into slabs.

A small tonnage of talc has been obtained in recent years from deposits at Mile 92, near D'Arcy, on the Pacific Great Eastern railway, Lillooet mining division. All of the talc taken out has been utilized for surfacing roofing paper, the principal operator being the Pacific Roofing Company, Granville island, Vancouver. The talc is grey-green in colour, carries minute specks of disseminated bornite, and grinds to a soft, nearly white powder. It shows evidence of crumpling, and breaks up readily into thin layers.

No work was done during 1920 on the steatite deposit near Vermilion Summit, Windermere mining division, but it is understood that the deposit has been found to extend beyond the limits of the original claim.

BENTONITE

Consequent upon inquiries directed to the Department by the Imperial Mineral Resources Bureau, regarding possible sources of bentonite in Canada, the writer was instructed to visit localities in Alberta and British Columbia, from which bentonite had already been recorded; to gather all available data regarding the occurrences; take samples, and to examine, also, any new deposits that might be brought to his attention. In accordance with these instructions, visits were made to three localities along the line of the Canadian National railway, between Edmonton and Calgary, and to one known occurrence in the interior of British Columbia. Samples were taken of the various beds examined, and the material was shipped to the Mines Branch laboratory for investigation as to its chemical and physical properties. Samples were also sent to the Imperial Mineral Resources Bureau, in order that similar work might be carried out upon the material by the Department of Scientific and Industrial Research.

The work being done in the Mines Branch laboratory has not yet reached a stage that will enable definite conclusions to be drawn regarding the suitability of these

poses. In some of the occurrences of this nature the principal salt present is sodium chloride, the other salts being present only in small quantities. The brine springs of northern Manitoba are good examples of this class of deposit.

Composition.—The composition of the salts occurring in these basins consists chiefly of mixtures of sodium and magnesium sulphates in varying proportions, with, generally, small quantities of sodium chloride and possibly other salts such as sodium carbonate, etc.

Sodium Sulphate

Sodium sulphate in the hydrous form (known as *Mirabilite* or *Glauber's Salt*) has the following composition:—

$$Na_2SO_4.10H_2O = \begin{cases} SO_3 & 24\cdot8\% \text{ (sulphur trioxide).} \\ Na_2O & 19\cdot3\% \text{ (soda).} \\ H_2O & 55\cdot9\% \text{ (water).} \end{cases}$$

In its pure state it is white, transparent to opaque, and has a hardness 1·5-2 with a specific gravity 1·48. It is readily soluble in water, and at first is cool to the taste, and afterwards saline and bitter.

Sodium sulphate in the anhydrous form (known as *Thenardite*) has the following composition:—

$$Na_2SO_4 = \begin{cases} SO_3 & 43\cdot7\% \text{ (sulphur trioxide).} \\ Na_2O & 56\cdot3\% \text{ (soda).} \end{cases}$$

Its colour, when pure, is white, translucent to transparent, and the mineral has a hardness of 2-3, with a specific gravity of 2·68.

Magnesium Sulphate

Hydrous magnesium sulphate (known as *Epsomite* or *Epsom Salts*) has the following composition:—

$$MgSO_4.7H_2O = \begin{cases} SO_3 & 32\cdot5\% \text{ (sulphur trioxide).} \\ MgO & 16\cdot3\% \text{ (magnesia).} \\ H_2O & 51\cdot2\% \text{ (water).} \end{cases}$$

This is a soft, white or colourless mineral, readily soluble in water, and with a bitter saline taste. Its hardness is from 2 - 2·5, and a specific gravity, 1·75.

Sodium Chloride

Sodium chloride (known as *Halite* or *Common Salt*) has the following composition:—

$$NaCl = \begin{cases} Na & 60\cdot6\% \text{ (sodium).} \\ Cl & 39\cdot4\% \text{ (chlorine).} \end{cases}$$

The natural salt is nearly always impure. It has a hardness of 2·5 and a specific gravity of 2·1 – 2·6. It is colourless or white when pure, but often yellowish, or red or purplish, from the presence of metallic oxides or organic matter. It is readily soluble in cold water, and has a saline taste.

With these salts may be associated other soluble salts such as sodium carbonate, and in small quantities, the salts of the calcium, potassium and alum groups.

On account of the nature of the natural alkali deposits and brines of western Canada, it will be necessary in nearly all cases to purify the raw product from such deposits, in order to produce marketable commodities. A pure Glauber's salt can be obtained by evaporating the brines or by dissolving the soluble salts already deposited and separating the sulphate of soda by differential crystallization. To produce salt

(*a*) *Where overburden is light.*—Residual river bottom areas usually have a relatively light overburden of clay, sand, and gravel. Where the thickness of overburden does not exceed 40 feet, exploration by means of test pits will usually be found satisfactory. In only three of the twenty-one test pits sunk during the past summer was cribbing necessary. In these three instances, caving was checked by using light poles and backfilling with brush. When the test pits have reached the bituminous sand, accurate core samples may then be secured by the use of standard asphalt hand augers. In sinking test pits, light pole derricks, rigged with double blocks, winding drum, and self dumping bucket, were used.

This equipment could be erected in from one to two hours. The weight of the heaviest single part did not exceed 75 pounds. A double action hand-pump, equipped with 10 feet of suction and 40 feet of discharge hose, was also used in order to keep down the very considerable volume of seepage water. Men worked in parties of three; but by using an efficient type of windlass, parties of two would have been adequate. The average rate of sinking, up to 25 feet, was approximately 3½ feet per day of 9 hours.

(*b*) *Where overburden is heavy.*—At points where a stream impinges against the side of a valley, exposures exhibit a thicker section of bituminous sand and also a much heavier overburden. Consequently, in determining the importance of areas represented by such outcrops, prospecting by means of test pits is not practicable. Usually, measurements, and boring by hand augers, along adjacent outcrops, will determine with sufficient accuracy the quality and quantity of the bituminous sand itself. It is more difficult, however, to determine definitely the thickness of the various strata of which the overburden consists. Under such conditions, two methods are possible:—

(i) A trench may be excavated above the outcropping bituminous sand, in order to expose a complete section of the overburden. The use of such a method is, however, rarely satisfactory. Slips in the unstable overburden along the precipitous slopes are frequent; and, apart from the large amount of excavation that trenching will ultimately involve, the final results are rarely reliable.

(ii) A bore may be sunk at some centrally located point within the area under consideration; and although such work involves the use of more elaborate equipment, the information secured is dependable. Light gasoline driven drills,[1] suitable for such work can be secured, of which the weight of the heaviest part does not exceed a few hundred pounds.

In preparing final estimates of quantities of overburden and of bituminous sand, accurate, detailed mapping is obviously essential. In the type of country under consideration the writer has found that maps, showing contours drawn at intervals of five feet, and plotted to a scale of one-inch equal to 200 feet, are satisfactory.

Conditions met with in the Horse River reserve may be considered characteristic of a large area lying south of township 93. As an indication of the importance that will attach to the removal and disposal of overburden, it may be stated that on the Horse River reserve, the estimated overburden amounted to approximately 3,180,000 cubic yards. The removal of this overburden would render available, approximately 3,360,000 tons of bituminous sand.

(II)

Classification of outcrops of bituminous sand with regard to their present possible economic importance.

Following the completion of the examination of the Horse River reserve, a short period was spent in visiting various outcrops of bituminous sand along the Athabaska and tributary streams, within the McMurray district. Conclusions arrived at as a result of the work on Horse river were of value in making a provisional classification of the various sub-areas represented by these outcrops.

[1] Manufactured by the Longyear Co., Minneapolis, U.S.A.

Analyses[1] of two samples of the shipping grade of feldspar from the O'Brien property yielded:—

Silica	65·09	65·80
Alumina	18·85	19·74
Ferric oxide	0·03	0·03
Lime	0·21	0·11
Soda	2·11	1·74
Potash	13·42	12·32
	99·71	99·74

It seems probable, in view of the encouraging results obtained by M. J. O'Brien, Ltd., on the above property, and the number of deposits carrying a similar grade of spar that have been located in the same district, that the Buckingham region will shortly become an important feldspar producing centre.

V

ALKALI DEPOSITS OF WESTERN CANADA

1921

L. Heber Cole

F. M. MacNiven, Assistant

Introductory

The search for potash in western Canada during the years of the great war led to the staking of claims on many of the alkali lakes and sloughs which occur in numerous localities in the morainic areas of the prairies, as well as in British Columbia, in the hope that potash salts would be present in commercial quantities. While the search for potash up to the present time, has been disappointing, the prospecting of the alkali deposits has demonstrated that western Canada possesses large reserves of sodium and magnesium compounds: such as sodium sulphate, sodium chloride, sodium carbonate, and magnesium sulphate.

Occurrences

Natural occurrences of soluble mineral salts are known in the provinces of Manitoba, Saskatchewan, Alberta, and British Columbia, either in the form of bedded deposits, or as brines. Some are of considerable extent, and are probably of sufficient size to warrant commercial exploitation, provided economical methods of recovery can be developed, and sufficient markets established.

The occurrences of these salts may be broadly classed under two types:—

(1) Solid salts and brines in undrained or partially drained basins.
(2) Brines of flowing streams or springs.

[1] Furnished by the operator.

the most westerly exposure. This lies about 450 yards west of the railway, with which the quarry is connected by a tram line. Work was commenced early in 1921, and a considerable tonnage of feldspar was shipped. The whole of the output went to the Orford Soap Company, Manchester, Conn., for use in cleanser preparations.

An analysis of the feldspar of this deposit made in the Mines Branch laboratory showed it to contain 1·62 per cent of potash and 7·14 per cent of soda.

During 1921 considerable interest was evinced in the feldspar deposits of the Buckingham district, in Labelle county. The development, during the year, of a large body of very high grade feldspar, by M. J. O'Brien, Ltd., on lot 8, range I of the township of Derry, has led to active prospecting in the adjacent territory, and a number of deposits have been discovered. Many of these occurrences will doubtless undergo development during 1922, and shipments have already been made from one or two deposits.

The property now being operated by M. J. O'Brien, Ltd., lies nine miles north of the town of Buckingham, Que., and two miles from the Lievre river. In summer, the feldspar is hauled by wagon to the river, and loaded into scows, which are towed down to the railway at Buckingham. In winter transportation is by sleigh on the river ice to the same point.

A large, well-equipped camp has been established on the O'Brien property. A small portable boiler supplies steam for two steam drills.

Feldspar is won from a single large opening. This is an open cut carried 130 feet into the upper portion of the ridge crossed by the deposit, and having a width of 35 feet, and about the same depth. The actual feldspar dike is somewhat wider than 35 feet, and averages about 50 feet. In mining, however, a band along the walls, consisting of a somewhat lower grade of spar, is left standing, to be taken down separately. It is intended to work this deposit—which has been proved for a length of 300 feet—by carrying in a series of benches at successive levels, and working out the feldspar the length of the deposit at each level. In this way, no hoisting is necessary, the feldspar and waste being run out of the cut by tram.

This deposit is remarkable for the unusually clean feldspar carried. An unusually small proportion of quartz is present in the dike, and this quartz occurs as segregations between large feldspar crystals, and can be readily removed separately. The accessory minerals so often present in feldspar dikes, such as tourmaline, hornblende, mica, garnet, etc., are virtually absent. The feldspar is predominantly of a light cream colour, and much of it is remarkable for its vitreous appearance and partial translucency. These are characteristics of the feldspar of many of the deposits recently uncovered in the same district, and in some cases, the colour is almost a pure white, the feldspar then having a remarkable milky appearance.

Type (1).—Those of the first class are very numerous in the prairie provinces, and are, generally, similar in character, although the percentage of the different salts varies in different localities. In many cases the name alkali lake has been appropriately applied to deposits of this nature, since in the early spring, and often into late summer, the deposits are covered with water. The water accumulating from the melting snow and rain is often a foot or two in depth, and carries a considerable quantity of the alkali salts in solution, due to the dissolving of the top layers of the crystallized salts. In the late summer, especially when the season is a dry one, these so-called lakes become deposits of white alkali, which when seen from a distance resemble snow covered basins. A day's rain, however, or a rise in temperature, which increases the solubility of the salts, will quickly cover the surface of the crystals with a saturated brine. This brine will, sometimes, entirely disappear during one night, if there is a fall in temperature.

The deposits vary greatly in size, some being many acres in extent, and ranging up to 15 feet or more in thickness. The salts are generally found interbedded or mixed with calcareous mud and peaty material, and in only a few instances are the deposits in a pure enough form to be commercially marketable in their crude state. In many cases the salt crystals contain included mud stringers, so that the salts would require to be redissolved, and the impurities allowed to settle out of the solution before a pure product could be obtained. The mud beds also contain numerous crystals of the alkali salts.

Type (2).—Brine streams or springs occur in many places, and may carry sufficient salts in solution to warrant their commercial exploitation for medicinal and other purposes. In some of the occurrences of this nature the principal salt present is sodium chloride, the other salts being present only in small quantities. The brine springs of northern Manitoba are good examples of this class of deposit.

Composition

The composition of the salts occurring in these basins consists chiefly of mixtures of sodium and magnesium sulphates, in varying proportions, with, generally, small quantities of sodium chloride, sodium carbonate, calcium carbonate, and calcium sulphate, etc.

SODIUM SULPHATE

Sodium sulphate in the hydrous form (*known as Mirabilite or Glauber's Salt*) has the following composition:—

$$Na_2SO_4 + 10H_2O = \begin{cases} Na_2O \ 19\cdot3 \text{ per cent (Soda)} \\ SO_3 \ \ 24\cdot8 \text{ per cent (Sulphur trioxide)} \\ H_2O \ \ 55\cdot9 \text{ per cent (Water)} \end{cases}$$

In its pure state it is white, transparent to opaque; and has a hardness of 1·5 to 2, with specific gravity 1·48. It is readily soluble in water, and at first is cool to the taste, and afterwards saline and bitter.

Sodium sulphate in the anhydrous form (*known as Thenardite*) has the following composition:—

$$Na_2SO_4=\begin{cases}Na_2O & 56\cdot3 \text{ per cent (Soda)}\\ SO_3 & 43\cdot7 \text{ per cent (Sulphur trioxide)}\end{cases}$$

Its colour, when pure, is white, translucent to transparent, and the mineral has a hardness of 2 to 3, with specific gravity 2·68.

MAGNESIUM SULPHATE

Hydrous magnesium sulphate (*known as Epsomite or Epsom Salts*) has the following composition:—

$$MgSO_4+7H_2O=\begin{cases}MgO & 16\cdot3 \text{ per cent (Magnesia)}\\ SO_3 & 32\cdot5 \text{ per cent (Sulphur trioxide)}\\ H_2O & 51\cdot2 \text{ per cent (Water)}\end{cases}$$

This is a soft, white or colourless mineral, readily soluble in water and with a bitter saline taste. Its hardness is from 2 to 2·5 and specific gravity 1·75.

SODIUM CHLORIDE

Sodium chloride (known as *Halite or Common Salt*) has the following composition:—

$$NaCl=\begin{cases}Na & 60\cdot6 \text{ per cent (Sodium)}\\ Cl & 39\cdot4 \text{ per cent (Chlorine)}\end{cases}$$

The natural salt is nearly always impure. It has a hardness of 2·5, and specific gravity 2·1 to 2·6. It is colourless or white when pure, but often yellowish, or red, or purplish, due to the presence of metallic oxides, or organic matter. It is readily souble in water, and has a saline taste.

SODIUM CARBONATE

Hydrous sodium carbonate (known as *Natron*) has the following composition:—

$$Na_2CO_3+10H_2O=\begin{cases}Na_2O & 21\cdot7 \text{ per cent (Soda)}\\ CO_2 & 15\cdot4 \text{ per cent (Carbon dioxide)}\\ H_2O & 62\cdot9 \text{ per cent (Water)}\end{cases}$$

This is very soluble in water, from which it crystallizes as such only below 20° C. It has specific gravity 1·4 to 1·7, and hardness 1 to 1·5.

With these salts may be associated other soluble salts, and in small quantities, salts of the potassium and alum groups.

Uses

Sodium sulphate in the anhydrous form is more commonly known by its trade name Salt Cake. As salt cake, it finds its chief use in the manufacture of sulphate pulp; in metallurgical work in the refining of nickel; in the manufacture of window, plate, and bottle glass; and in making water glass. In the hydrous form, it is marketed as Glauber's Salt, and as such, is used in tanning; in the textile industry as a mordant; and in medicine.

Hydrous magnesium sulphate or Epsom Salts is largely used in the cotton trade for warp-sizing; it is also employed for medicinal and agricultural purposes, and in dyeing with aniline colours, since goods thus dyed are found to withstand better the action of soap.

Sodium chloride is the ordinary Common Salt of commerce, and as such, has many uses.[1]

Sodium carbonate in the anhydrous form, known under the trade name of Soda Ash, is one of the principal forms in which sodium is used in the alkali industry, since it frequently forms the base from which other sodium compounds are made. It is used extensively in the manufacture of glass, soap, and dyes, as well as in cleansing preparations, and tanning. In the hydrous form it is marketed under the trade names of Sal Soda, Washing Soda, or Crystal Carbonate, and is used in softening water and to replace soda ash when purity is essential. It is also used in cleansing compounds, or alone as washing soda. Sodium bicarbonate, or acid sodium carbonate, commonly known as Baking Soda, is generally marketed in a very pure form, and finds its principal use in baking.

Methods of Examination

The alkali deposits of western Canada are very numerous, and are scattered over a wide territory. On account of the great similarity of many of the deposits, it was thought best to confine detail work to several of the more typical deposits as representative of a district, and to obtain general data on the others.

Field Work

The field work on the deposits where detailed work was done consisted of:—

(1) Transit survey of the deposit and surrounding area, with contours at 10-foot intervals, sufficient to show the presence or absence of drainage to or from the deposit; also the location of springs and wells which might have any bearing on the source of the deposit.

(2) Detailed surface examination of the area included in the survey to determine the nature of soil and rocks of the surrounding country.

(3) Core drilling at regular intervals over the whole deposit, to determine its extent, depth, and composition.

(4) Sampling of all springs and wells in the area, and representative samples from all the cores obtained in the drilling operations.

(5) Collection of all data having any bearing on alkali deposits.

(6) Chemical analyses in the field, to quickly determine the quality of material in any deposit.

The field work on other deposits not studied in detail, consisted in visiting such deposits and obtaining representative samples from test pits, as well as brine samples from any springs feeding such deposits. In each case, general estimates of the size of such deposits were made from the township plans, and all available data collected.

[1] For details relative to the uses of Common Salt the reader is referred to "The Salt Deposits of Canada and the Salt Industry." No. 325, Mines Branch, Dept. of Mines. L. Heber Cole, 1915.

Apparatus and Methods

In surveying the lakes, a small light transit was employed, and measurements made with stadia. The elevations were determined by means of hand level.

The drilling was done with a power drill, built especially for this investigation, by the E. J. Longyear Company of Minneapolis, Minn., U.S.A. It consists of a type BD diamond drill, together with a hoist and a 2-inch by 3-inch Gould triplex pump, all operated by an 8 horse-power Cushman gasoline engine and mounted on a platform. The platform is bolted to a steel frame on wheels, so that the whole outfit is easily moved from place to place.

The entire weight is approximately 3,600 pounds.

In place of using diamonds for the bits, pieces of hardened steel with chisel edges were placed in the bit, and these were found to give good results. On account of the friable nature of the material being drilled, great care had to be taken in order to obtain satisfactory cores, since excessive vibration or too high a speed tended to break up the core into individual crystals. A saw tooth bit was tried, but it tore the crystals apart, instead of cutting them.

The drill is adapted to recover 1 inch and 2 inch cores.

A 200-foot steel cable attached to the hoist drum enabled the drill to be moved from place to place on the deposit, by its own power. When moving from one deposit to another the drill was hauled behind a Ford truck.

A complete chemical outfit for making preliminary analyses of samples in the field was included in the equipment. Aside from a standard Becker balance, Ralston still, and two coal oil burners, which were carried separately, the entire chemical apparatus was packed in two cases, with trays so arranged that any article could be taken out without having to remove all the apparatus. These boxes weighed, approximately, 300 pounds, and were shipped by freight to the west from Ottawa, and carted around from place to place without any breakage.

This outfit was sufficient for the determination of the principal salts in the lakes, and the composition of any deposit was quickly ascertained in the field. This knowledge was of great value in eliminating those lakes whose analyses showed them to be of no immediate commercial importance.

Description of Deposits

The following brief descriptions of deposits are of a preliminary nature, and only a few are given as typical of many examined.

Some of those visited, such as the large lakes south of Ceylon, Sask., and the one at Horizon, Sask., were covered with a considerable depth of water at the time, consequently little information was available.

Frederick Lake, Expanse, Sask.

This lake, situated in parts of sections 20, 21, 28, 29 and 33, township 12, range 28, W. 2nd meridian, was studied in detail, in order to obtain information relative to the nature of such deposits as would be applicable to all deposits of this character.

Frederick lake occupies a depression between a number of morainic ridges of the Missouri couteau, and covers an area of, approximately, 825 acres. It has a solid crystal bed composed principally of Glauber's Salt, with a small percentage of Epsom Salts.[1] It is separated from Johnson lake, on the north, by a narrow ridge composed of sand and gravel, which rises in places 30 to 40 feet. The level of Frederick lake is, approximately, 3 feet lower than Johnson lake. There is no apparent outlet, and some of the adjacent morainic ridges rise to a height of over 100 feet above the level of the crystal bed. Three springs feed into the depression from the shores. Analyses of these springs are given elsewhere in this report. Springs Nos. 1 and 2 are very similar in composition. Spring No. 3 varies considerably from the other two, but is very similar in composition to the water in Johnson lake. Inasmuch as this spring is situated on the shore of the lake nearest Johnson lake, it is quite probable that it is the result of seepage from the larger lake.

It is probable that at one time this lake was a bay of Johnson lake, since there are strong indications of beaches on the morainic slopes surrounding the lakes, at an elevation of from 30 to 40 feet above the present level. A rise of 40 feet in the present level of the water of the lake would submerge the narrow neck of land separating the two lakes, under about 10 feet of water. Conditions would, therefore, be favourable in this particular instance for the deposition of salts in the present basin of Frederick lake as a partially entrapped arm of the larger body of water of Johnson lake.

A series of some 65 holes were drilled over this deposit, and it was found that the hard crystal bed averaged 4·2 feet in depth. Beneath the crystal bed was a varying thickness of silty mud with salt crystals interspersed through it, and resting on a compact stoneless and highly calcareous clay. One typical hole drilled gave the following results:—

0 — 5′ 6″ hard, compact crystals.
5′ 6″—10′ 0″ soft mud and crystals.
10′ 0″—15′ 0″ silty clay, calcareous (stoneless).
15′ 0″—20′ 0″ coarse sand, calcareous bond.
20′ 0″—28′ 0″ boulder clay.

The materials comprising the surrounding country are boulder clay, gravel, sand, and silty clay.

The Canadian Pacific railway branch line from Moose Jaw to Assiniboia, Sask., runs along the south shore of this lake. A siding 200 yards long has been built at the lake.

Corral Lake, Sask.

This lake, situated on sections 14 and 23, township 14, range 20, west 3rd meridian, is, approximately, 12 miles northwest of the town of Gull Lake, Sask.

The deposit lies in an undrained depression in the eastern edge of the great belt of sand hills extending along the north side of the main line of the Canadian Pacific railway, between Swift Current and Maple Creek.

[1] Analyses of material from this deposit are given elsewhere.

The surrounding hills at this deposit are composed entirely of sand, no boulder clay or gravel area of any extent being noticed.

The deposit covers an area of 60 acres, and 15 test holes proved an average crystal bed of 5 feet.

There is one spring feeding this lake at the south end.

Alkali Lake near Ingebright, Sask.

This deposit occupies parts of six sections and is situated in sections 13 and 14, 23 and 24, 25 and 26 of township 16, range 25, west of the 3rd meridian.

By road, it is 40 miles almost directly north of Maple Creek, Sask., the nearest point on the railway.

The lake bottom is covered with a thick bed of hard crystals.

There are several springs along the shore, feeding into the lake, and in the deposit itself there are numerous springs coming up through the crystal bed. Some of these springs are 6 feet and 8 feet in diameter. When the deposit was visited October 24, 1921, there was one foot of water over the surface of the whole lake. This surface water was a saturated solution of sodium and magnesium sulphates.

There are 17 claims staked on this lake, under the Quartz Mining Regulations.

The impurity in the salts consists of sand rather than silt, such as is found in other deposits examined. One can walk onto the lake at almost any point, for the crystal bed is firm right to the shore. The shore is very sandy, and the banks, in most cases, are steep, rising from 10 to 40 feet above the lake level at a distance of 50 feet back from the shore.

The most noticeable feature of this lake, apart from its size, and the large amount of crystal present, is the numerous springs in the crystal bed at the north end of the lake. Many of these springs are bubbling up, and constantly depositing crystals in cones. It is said that in dry weather these springs build up cones, in places, to a height of 15 feet. Even with a foot of water on the surface of the crystals, these cones were noticed in the process of formation, projecting a few inches out of the water. No data were obtained as to the depth and tonnage of salts in this deposit, but it is evident that it is quite large.

Fusilier Deposit

(On the Lacombe-Kerrobert branch of the C.P.R.)

This deposit, owned by the Soda Deposits Ltd., Calgary, Alta., is situated on section 17, township 34, range 26, W. 3rd meridian, on Plover lake. Two claims of 40 acres each are located on this lake, taking in the whole area of the lake. When visited on Oct. 25, 1921, there was about one foot of water over the whole surface of the lake.

There are a number of springs feeding this lake, and the depth of the clean crystals on the top will average about 3 feet. The salts are practically pure sodium sulphate.

This deposit is being operated in a small way, and several thousand tons of clean salts have been excavated. These salts have been piled on the shore, and are gradually being dehydrated in drying sheds which have a capacity of 5 tons every two weeks. A service truck is being used to haul the material 5½ miles to the Canadian Pacific Railway station at Fusilier, Sask., where a warehouse 24 feet by 40 feet has been erected.

Senlac, Sask.

An interesting lake was examined on sections 19 and 30, township 39, range 25, west 3rd meridian. This lake is 12 miles north of Denzil, Sask., and 8 miles east of Evesham, Sask. The area of the lake is 185 acres, and, unlike many of the other lakes examined, the salt present is sodium chloride. The lake is fed by numerous springs, and a company known as the Senlac Salt Co., Calgary, Alta., has done considerable development work. The springs, which are very numerous, occur over various parts of the lake, and the degree of saturation of the water in the lake varies at different times of the year.

The company operating this lake built wooden cribbing around a number of the springs, and pumped the brine to shallow mud vats built on the shore. The solar system of evaporation was employed, and when the evaporation was completed the salt was shovelled onto drying boards, and allowed to drain, after which it was bagged and sold locally. There is also a small plant with two open pans operated by direct heat supplied by coal fires.

When the property was visited on Oct. 26, 1921, the whole plant was idle.

Two samples of the salt, furnished by the company, were analysed:—

	No. 1 coarse	No. 2 fine
Na	38·13%	36·87%
K	none	none
Mg	0·23	0·45
Ca	0·05	0·18
SO_4	0·08	0·35
Cl	59·43	58·14
Insol. in water	0·34	0·09
Loss at 110° C	1·02	2·24
Loss above 110° C	1·18	2·00
	100·46	100·32

A. Sadler, Analyst, Mines Branch.

Whiteshore Lake

This lake is situated in the northern part of township 36, ranges 16 and 17, west 3rd meridian. It is close to the stations of Oban and Palo on the main line of the Canadian Government railway, and Naseby, on the Winnipeg-Edmonton line of the Canadian Pacific railway. Its area is, approximately, 9 square miles.

When this deposit was visited, October 26, 1921, there was a foot of saturated brine over the whole surface of the deposit.

The clear surface deposit of crystals varied from a thin film to over 8 inches, underneath which is a thin layer of mud. Beneath the mud there is another bed of hard crystals of varying thickness, mixed with considerable mud.

An average percentage composition of the deposit, as calculated from a number of analyses, is shown in Table No. I, column 2.

Muskiki Lake (Dana, Sask.)

Muskiki lake, situated in townships 38 and 39, ranges 26 and 27, west of the 2nd meridian, contains large quantities of sodium and magnesium sulphates, as well as small percentages of other salts. The area of this lake is, approximately, 4,600 acres.

The property is owned by Salts and Chemicals, Ltd., Kitchener, Ont., and this company has done a large amount of experimentation on the recovery of the salts in a commercial form, both at their plant at the lake and at their refining plant at Kitchener, Ont.

The country surrounding this lake is rolling prairie, and the lake is the lowest point for some miles around. There is no apparent outlet, and there are numerous springs feeding into the lake around the shores and in the lake itself. One group of springs was very noticeable, about 10 feet from the shore on the east side, bubbling up and keeping the surface water in constant agitation. The shore at this point is built up of calcareous sinter intimately mixed with an ochre. The gravelly material making up the beach shingle for quite a distance on the south side of this point is made up of nodules of tufa in varying sizes. These materials are probably deposition products from the springs.

The deposit of salts in the bed of this lake varies greatly in thickness from place to place. It is composed chiefly of Glauber's Salts, with an average of 10 per cent of Epsom Salts. The lake brine, on the other hand, runs high in magnesium sulphate and also carries a small percentage of potash salts.

The crystallized salts in the bed of the lake are harvested as such, when conditions are favourable, and stored in drainage sheds at the lake. When sufficiently drained they are shipped to Kitchener, where the refining of the salts for the market is accomplished. The brine is evaporated in the plant at the lake, from whence the crude salts are shipped to Kitchener, for the recovery of refined Epsom Salts, as well as magnesium carbonate and potash salts.

Chemical Analyses

A number of analyses given below show the wide variation in the composition of the lakes visited.

Frederick lake, about 3½ miles from Expanse, Sask., was examined first, and a number of samples from various parts were taken. The deposit of crystals varied in thickness from a few inches at the edge to about 5 feet in the middle. Core samples were taken, and an analysis was made of each foot, thus giving an idea of the uniformity of the bed. Some of the results are given below.

Hole No. 3—Frederick Lake, Expanse, Sask. Crystal bed 3 feet thick.

—	1st foot	2nd foot	3rd foot	[1]Composite
Insoluble	0·78	3·53	1·49	1·86
Iron oxide and alumina	0·06	0·20	0·09	0·20
Calcium carbonate	1·70	5·85	2·10	2·17
Magnesium carbonate	0·76	3·70	2·70	1·62
Magnesium sulphate	2·63	2·17	4·01	3·30
Sodium chloride	0·61	0·46	1·39	1·02
Sodium sulphates	92·80	83·65	88·09	89·28
Total	99·34	99·56	99·87	99·45

Hole No. 1—Crystal bed 4 feet thick

—	1st foot	2nd foot	3rd foot	4th foot	[1]Composite
Insoluble	2·54	3·30	3·46	3·55	3·49
Iron oxide and alumina	0·12	0·42	0·21	0·18	0·15
Calcium carbonate	2·53	2·04	4·08	3·13	2·88
Magnesium carbonate	1·65	1·15	3·67	2·32	1·11
Magnesium sulphate	5·25	5·32	4·20	5·25	6·03
Sodium chloride	0·90	0·98	1·02	1·00	0·87
Sodium sulphates	86·06	86·38	83·06	84·52	85·29
Total	100·05	99·59	99·70	99·95	99·82

[1]The composite was not made up from the samples for each foot but was an independent sample through the crystal bed.

The water from several springs flowing into this lake was analysed, and the results are given below in parts per 1,000,000.

—	No. 1 spring	No. 2 spring	No. 3 spring
Insoluble	30·2	30·0	20·0
Iron oxide and alumina	7·9	3·6	5·6
Calcium carbonate	310·4	304·2	....
Magnesium carbonate	209·8	242·0	180·6
Magnesium sulphate	....	....	1,222·0
Sodium chloride	5·14	8·8	....
Sodium sulphate	968·8	925·8	4,395·0

Corral lake situated about twelve miles north of Gull lake, Sask.

[1]*Hole No. 1—on the shore*

—	1st foot	2nd foot	3rd foot	4th foot	5th foot
Insoluble	70·09	67·80	59·13	67·87	70·52
Iron oxide and alumina	1·83	1·60	1·50	0·42	0·63
Calcium carbonate	0·84	0·35	0·68	0·71	1·49
Calcium sulphate	....	....	....	....	2·07
Magnesium carbonate	1·36	....	1·47	....	....
Magnesium sulphate	....	1·94	2·11	1·83	3·50
Sodium chloride	0·60	0·50	0·40	0·55	0·81
Sodium sulphate	25·03	27·55	34·64	28·10	20·69
Total	99·75	99·74	99·93	99·48	99·71

[1]This hole was sunk to ascertain whether the crystal bed extended farther than was indicated on the surface.

Hole No. 3—Typical sample of the deposit

—	1st foot	2nd foot	3rd foot	4th foot	5th foot
Insoluble	14·74	8·04	9·73	9·11	11·80
Iron oxide and alumina	0·10	0·004	0·005	0·008	0·008
Calcium carbonate	2·22	0·86	0·95	0·76	0·86
Magnesium carbonate	4·01	2·06	2·13	2·10	1·53
Magnesium sulphate	....	....	....	....	1·24
Sodium chloride	0·29	0·25	0·25	0·25	0·29
Sodium sulphate	78·32	87·89	86·56	87·49	83·93
Total	99·68	99·10	99·62	99·71	99·66

This lake is surrounded by sandy land, which may be either washed or blown on to the deposit, hence the high percentage of insoluble material.

The analyses of crystal beds in several lakes are given in the columns of Table I, and of brines in Table II.

TABLE I

Constituents	Lake near Gladmar, Sask.	Oban, Sask. Whiteshore lake	Lake Alta.
	%	%	%
Insoluble	trace	0·1	14·03
Iron oxide and alumina	absent	....	....
Calcium carbonate	absent	....	0·59
Calcium sulphate	....	0·5	....
Magnesium carbonate	absent	....	1·10
Magnesium sulphate	....	5·2	....
Sodium chloride	0·12	1·3	0·10
Sodium sulphate	99·49	92·0	84·18

Column 1—Only pure crystals were taken in the analysis—E. A. Thompson, analyst.

Column 2—Average analysis made by Dr. Thorwaldson, Saskatchewan University.

Column 3—Analysis made by H. A. Leverin, Mines Branch, Ottawa.

TABLE II

Constituents	1 Parts per million	2 Parts per million	3 Parts per million	4 Parts per million	5 Parts per million
Organic matter	68·4	6·7	8·3	....	477
Suspended matter	123·5	17·8	208·6	....	....
Silica	1·4	13·5	69·1	0·22	....
Iron oxide and alumina	27·3	0·9	25·0	0·085	nil
Calcium carbonate	trace	121·9	trace	2·055	nil
Calcium sulphate	195·3	322·7	895·1	17·84	nil
Magnesium carbonate	501·3	192·3	309·6	0·186	146
Magnesium sulphate	197·7	....	1,232·0	56·24	....
Sodium chloride	58·3	15·4	96·7	17·84	823
Sodium sulphate	441·4	133·9	1,685·6	68·02	358
Potassium chloride	....	....	....	1·63	....
Sodium carbonate	....	....	....	2·25	3,410

1. York lake, Melville, Sask.
2. A lake near Duff, Sask.
3. Water, Talmage, Sask.
4. Big Quill lake, Wynyard, Sask.
5. Soda lake, Maidstone, Sask.

Preparation for the Market

In preparing this product for the market, the guiding principle, of course, will be the specifications laid down by the consumer. There are several markets for sodium sulphate. The chief ones, or those which would probably take the large tonnages, are the paper industry, in which the salt is used in the manufacture of sulphate pulp, or, more correctly, sulphide pulp, and in the manufacture of glass.

As to the glass industry, we have been unable to get a copy of the exact requirements, but the chief ones are (1) that the material be dry; and (2) that the iron content be very low, possibly in no case above ·02-·03%.

A small percentage of insoluble material, if siliceous in nature, would not be objectionable, and small amounts of magnesia and lime would probably be permissible. It is to be remembered, however, that the soda base is the essential constituent, and that the materials mentioned above are to be regarded as impurities which may lower the effective value of the product.

Relative to the requirements of the paper industry, we are indebted to Dr. McLean of J. T. Donald and Company, Ltd., Montreal, for the analysis of a shipment of salt cake, which was accepted and used in the manufacture of sulphate pulp. He said that the analysis mentioned could be taken as a standard.

The following is the analysis of a shipment of salt cake obtained as a by-product in the manufacture of hydrochloric acid:—

	per cent
Moisture	0·24
Silica	0·19
Iron oxide	0·45
Alumina	trace
Sodium chloride	2·15
Free sulphuric acid	1·96
Sodium sulphate (calc.)	95·01

Less than 1 per cent sodium chloride is advisable, and not more than ·5 per cent iron; free sulphuric acid appearing in the analysis would not be found in the product of the alkali lakes. No allowance is made for calcium and magnesium sulphates. They would probably not prove detrimental to the product. It is thought that the magnesium salt would make the paper a little more flexible, although, perhaps, a little heavier. Possibly 5 per cent of each of these salts would be allowed, but so large an amount of impurities would, very appreciably, lower the value of the salt cake.

Keeping in mind, therefore, the specifications required, only those deposits which run approximately 90 per cent or over, sodium sulphate, in the dry state, should be worked at the present time.

The proximity of the deposit to a railway is also of the utmost importance, because of the cost of haulage.

Sodium sulphate, as it occurs in the lakes, is in the form of crude Glauber's salt. If the insoluble material (sand, organic matter, etc.) is high, it will have to be removed first. This may be done by bringing the salt into solution in water and then allowing the insoluble to settle out in settling tanks. The clear solution may then be decanted into crystallizing pans or tanks, and the salt allowed to crystallize out.

DRYING PROCESSES

There are a number of methods suggested for the dehydration of Glauber's salt. Some of these are given below.

Air Drying.—As is well known, Glauber's salt when exposed to the air loses its water of crystallization, and forms a fine white powder of anhydrous sodium sulphate. In this process, the hydrated crystals are exposed to the air, on trays with cotton bottoms which allow the air to circulate freely through the material. About two weeks is required to lower the moisture content from 56 per cent, approximately, to 15 per cent. The material is removed to a building where it is placed on trays, and the last traces of water are easily removed in a day or two by the heat of a stove.

This method is in operation at an alkali lake 5½ miles from Fusilier, Sask. The company has erected a building or shed about 10 feet high by 12 feet wide by 100 feet long. In this shed, the trays are arranged in rows, one above another, about two inches apart, and are filled with hydrated crystals. The trays are pushed along one following another until the shed is filled. The sides of the shed are built in sections or doors on hinges, which open from the top, and lie back on the ground. This allows the air to circulate above and below the exposed crystals, and thus carry off the water. About five tons of the dried material is obtained in this way,

in two weeks. Two men can easily fill or empty the shed in one day. In order, then, to have an output of five tons per day, fourteen sheds of the size stated above would be required. This would necessitate quite an initial outlay, and the cost of maintenance would be considerable. However, this method is probably the most economical that has been devised so far.

Direct Evaporation of the water.—One method is, to heat the salt in large open iron pans, and to expel the water by direct evaporation. There are two main objections to this method: (1) that the dried salt cakes solidly in the pans, and would have to be loosened with picks, which would increase the cost; and (2) the cost of fuel in heating.

Rotating dryers have been suggested for drying purposes, but whether these would work on material which goes into solution in its own water of crystallization when the temperature is raised is doubtful. At about 33° C., approximately 30 per cent of the sodium sulphate in solution is precipitated, and forms a rather pasty mass. Special experiments will have to be conducted in order to ascertain whether the material would cake in the dryer, and thus clog it.

Cement kilns with certain modifications have been used in drying solutions of potassium salts. At the upper or feed end of the kiln, the inside was lined with 2 inch by 4 inch scantlings, placed lengthwise and on edge about 2 inches apart, blocks being inserted between to hold them rigidly in place. Then, at the end of the scantlings, the kiln was lined with 2 inch by 4 inch scantlings placed side by side for about 6 feet. The heat was applied at the lower end by either pulverized coal, oil, or gas.

The solution was fed in a constant stream and ran into the spaces or troughs between the scantlings. As the kiln revolved, the solution was carried up and then poured out through the hot gases, finally falling to the bottom only to be taken up again. The solution becoming more concentrated all the time, gradually worked forward, until finally all the water was expelled, and only the salts were left. These issue at the firing end as in cement making. The inside of the kiln at the feed end was arranged with alternate troughs and complete bands, but this work was only carried to a point where the lining was not affected by the heat. Looking into the kiln from the feed end, the appearance was strikingly similar to a shower of rain.

Unless this method could be used when feeding Glauber's salt crystals it is evident that it would be less economical than evaporation in open pans. Then, too, power would be required to rotate the kiln.

On account of the salt coming in direct contact with the fuel, the dried material may be contaminated with coal dust, if that is used for fuel.

Production and Market Conditions

Sodium Sulphate.—The production of sodium sulphate from the natural deposits of western Canada is still in its infancy. There is a small but fairly steady market for this material in the anhydrous form in the pulp and paper industry, but the consuming centres are in eastern Canada, and the present high freight rates from the deposits to the markets are an important factor. Very little of the crude material, as such, can be marketed, and this necessitates the installation of refining plants.

The product has to compete against that produced as a by-product from acid manufacture, but there are hopes that simple refining methods and lower freight rates will eventually help this industry.

The Salts and Chemicals Ltd., of Kitchener, Ont., operating Muskiki lake, Sask. (townships 38 and 39 ranges 26 and 27, west 2nd meridian), as already stated, have erected refining plants at their lake, and also at Kitchener, Ont., in which they have conducted much experimental work, and hope shortly to be in a position to place refined products regularly on the market. The Soda Deposits, Ltd., operating Plover lake, Sask., (township 34, range 27, west 3rd meridian), have been producing small quantities of high grade anhydrous sodium sulphate.

Frederick lake, near Expanse, Sask. (township 12, range 28, west 2nd meridian), will likely be a producer shortly, as a plant is now being installed by the Bishopric and Lent Co., of Cincinnati, Ohio. There are many deposits which could produce sodium sulphate, but only those close to the railways can be considered at the present time as prospective producers.

Practically all the salt cake so far used in the country has been obtained as a by-product from the manufacture of hydrochloric acid. The amount produced by this process in future will necessarily be governed by the market for hydrochloric acid.

Salt cake is being produced in Canada by the following firms:—

Grasselli Chemical Co., Hamilton, Ont. (by-product).
Nichols Chemical Co., Montreal, Que.
Plants: Sulphide, Ont. (by-product).
Capelton, Que. (by-product).
Canadian Explosives, Ltd., James Island, B.C. (by-product).
Salts and Chemicals, Ltd., Kitchener, Ont.
Plants: Kitchener, Ont. (natural).
Dana, Sask. (natural).
Soda Deposits, Ltd., Calgary, Alta.
Plant: Fusilier, Sask. (natural).

The Canadian production of salt cake and Glauber's salt as furnished by the Dominion Bureau of Statistics for 1918-1921 was as follows:—

—	1918		1919		1920		1921	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value
		$		$		$		$
Salt cake	6,001	133,544	3,197	57,045	5,524	111,983	2,418	54,804
Glauber's salt	2,358	60,281	1,423	45,731	1,781	50,336	1,239	42,719

Canadian imports of salt cake and Glauber's salt are as follows:—

Calendar Year	Salt cake		Glauber's salt	
	Amount	Value	Amount	Value
	lbs.	$	lbs.	$
1910	17,728,543	95,054	1,080,309	5,217
1911	13,782,241	88,761	1,531,555	7,826
1912	19,243,823	97,768	1,951,619	9,129
1913	25,902,190	133,030	811,053	3,815
1914	38,175,604	170,333	810,062	3,407
1915	30,970,231	147,047	840,994	8,058
1916	42,194,077	178,370	522,703	8,133
1917	71,583,645	560,711	722,913	16,248
1918	68,773,441	676,571	686,712	9,748
1919	47,905,004	343,007	738,423	9,763
1920	85,948,000	958,628	565,746	8,364
1921	54,379,450	680,083	579,928	4,521

Magnesium Sulphate.—There is a small production of magnesium sulphate from the natural deposits of western Canada, the main producing districts being, five lakes near Basque, B.C.; a lake near Clinton, B.C.; and Muskiki lake at Dana, Sask. A big deposit is located near Kruger mountain, B.C., and it is possible that some of the alkali deposits of Saskatchewan and Alberta may, in time, become producers.

The market for this material remains quiet. The producing localities are unfavourably situated as regards the present market in eastern Canada, hence there is still a considerable import, mainly into the markets of the east. The Canadian production, however, seems to have caused a noticeable reduction in the import figures for 1921.

The Canadian producers of magnesium sulphate are:—

The Basque Chemical Production Co., Ltd., Vancouver, B.C.
Plant: Basque Ranch (near Ashcroft, B.C.).
Stewart-Calvert Co., Inc., Oroville, Washington, U.S.A.
Plant: Clinton, B.C.
Salts and Chemicals, Ltd., Kitchener, Ont.
Plants: Kitchener, Ont.
Dana, Sask. (Muskiki lake).

The production, imports and exports of magnesium sulphate are as follows:—

	1917		1918		1919		1920		1921	
	Tons	Value	Tons	Value	Tons	Value	Tons	Value	Tons	Value
		$		$		$		$		$
Quantity extracted	2,600	....	4,500	....	......	....	2,056	....	......	....
[1]Quantity shipped	929	4,645	1,949	14,565	738	9,115	1,125	28,137	614	20,961
Exports	......	....	......	....	......	15	743	3,737	119	4,562
Imports	......	....	......	....		(a)54,779	......	72,709	......	29,987

(a) Not separately classified prior to April, 1919.
[1]Figures furnished by Dominion Bureau of Statistics.

Market Prices.—The market prices for alkalis are constantly varying. The following figures, as reported in the Oil, Paint, and Drug Reporter, New York, give the New York market prices for the years 1914 to date:—

—	Aug. 14, 1914	Jan. 1, 1915	Jan. 1, 1917	Jan. 1, 1918	* 1919	* 1920	* 1921
	$	$	$	$	$	$	$
Salt cake, ground—bbls. per ton........	11·00 to 13·00	11·00 13·00	....	30·00 to 35·00	12·00 to 30·00	17·60 to 80·00	17·00 to 28·00
Glauber's salt—cwt..	0·65 to 0·75	0·60 to 0·75	0·60 to 0·65	0·90 to 1·00	1·00 to 2·25	1·15 to 2·65	1·00 to 1·75
Epsom salt, U.S.P—cwt................	Not quoted prior to 1918			3·62½ to 3·90	2·75 to 3·62½	2·50 to 5·50	2·20 to 2·75
Epsom salt, tech.—cwt................	1·00 to 1·10	1·75 to 2·00	1·75 to 1·85	3·37½ to 3·50	1·80 to 3·37½	1·75 to 3·50	1·10 to 1·75

*High and low figures for year.

VI

CRETACEOUS SHALES OF MANITOBA AND SASKATCHEWAN, AS A POSSIBLE SOURCE OF CRUDE PETROLEUM

S. C. Ells

INTRODUCTORY

During recent years attention has been directed to reported occurrences of oil shale in the provinces of Manitoba and Saskatchewan. The shales are exposed along the escarpment of the Pembina, Riding, Duck, and Porcupine mountains, which border the lake plain and Red River valley of Manitoba. They are also found in the escarpment of the Pasquia hills, a northern extension of the same series. These hills, dignified by the name of mountains, constitute the erosion escarpment of the Cretaceous beds which form the first prairie step. The eastern edge is indented by drainage valleys of varying importance, which separate the hill features into groups. The Pasquia hills, and Porcupine, Duck, and Riding mountains, occupy an area which is bounded toward the north and northwest by the Carrot river, and toward the east by waterways, which include Moose lake, Cedar lake, and lake Winnipegosis. Broad, low-lying, slightly undulating, lacustral plains, which formed the bed of glacial Lake Agassiz, stretch away from the various waterways of the lower slopes of the hills. These lower slopes are marked by a series of old lake beaches, and rise by easy gradients, through some five or six hundred feet, to the more abrupt escarpment of the main ridge.

The whole area is well watered by numerous small streams few of which have a width greater than 60 feet. In descending from the table lands, these streams, for the most part, flow with rapid current along boulder-strewn channels, deeply entrenched in precipitous valleys and ravines, where active erosion and landslides are much in evidence. On reaching the lower slopes of the hills, the current slackens, and many excellent geological sections are exposed in cut banks at concave bends.

New Brunswick

A number of samples of rather highly coloured clays were submitted by interested parties in St. John, to be examined as possible raw material for the manufacture of paints. They consisted of red, buff and yellow clays, which, when ground in oil, produced paints of poor quality as to opacity, intensity of colour and brilliance, except in the case of the yellow clay, which may be classed as a fairly high grade yellow ochre. The other colours were unsuitable as pigments, except possibly as cheap fillers for linoleum manufacture.

Opportunity offered to visit the deposits from which the above mentioned samples were obtained and an examination was made of them in October.

Northumberland County.—About six miles southeast of Howard station, to the west of Cain river, between Otter brook and the mouth of Sabbies river, there are several exposures of coloured clay. In the bed of a small creek in the southern part of the area indicated above, an unctuous blue-grey clay outcrops from under about five feet of gravel. Within this bluish clay are streaks and small pockets of bright yellow ochre of good grade, but as the quantity apparently is very small, and also due to its mixture with the other clay, it is of no commercial value.

To the northward there are a number of clay areas many acres in extent. The general colour of this clay is buff, though the upper half foot is frequently of a stronger yellow colour. None of it is suitable for paint manufacture.

Kings County.—Clays resulting from the weathering of Carboniferous shales are exposed along the sides and floor of a small valley on the road from St. John to Smithtown, near Damascus. The prevailing colour of the clay is red, but it contains streaks and small patches of greyish white silty clay and yellow clay.

The red clay is similar to much occurring throughout New Brunswick and Nova Scotia. It cannot be regarded as valuable for pigment purposes as it lacks brilliance of colour and opacity when ground in oil. It might be used as a filler in the manufacture of linoleum. The white silty material is worthless. The yellow clay would make good paint similar to French yellow ochre, but it occurs in too small quantity to be of any value, and the indications do not point to the likelihood of more extensive deposits.

II

ALKALI DEPOSITS, WESTERN CANADA

L. H. Cole

INTRODUCTORY

The examination of the alkali lakes of western Canada, begun during the field season of 1921, was continued during the summer of 1922. The work was hindered to some extent during the entire season by the unusual amount of rainfall which occurred in the localities in which the lakes are situated. None of the deposits examined were entirely dry at any time during the work, and most of the drilling was carried on with from six inches to one foot of brine on top of the crystal bed.

The methods employed in the examination were the same as those of the previous season, a description of which is given in the Summary Report of the Mines Branch for 1921. The work was commenced at Vincent lake, 12 miles northwest of Tompkins, Sask., and the season was spent in the area lying to the west of Swift Current, Sask., between the main line of the Canadian Pacific railway and the Empress branch of the same line.

SODIUM SULPHATE DEPOSITS

Three large deposits were drilled and sampled and preliminary work was done on a dozen other deposits.

The deposits examined were very similar to those previously studied. The thickness of the crystal bed varied greatly in the several deposits, and also from place to place in the same lake. One drill hole cut through 30 feet of solid crystals before encountering the underlying mud. This is the greatest depth of crystals so far proven by the investigation.

The drilling done to date on six deposits has proven the presence of 17,000,000 tons of crystals, 90 per cent of which can be considered hydrous sodium sulphate.

Description of Deposits

The following brief description of the deposits examined during the season is only preliminary and will be supplemented in the final report.

Vincent Lake, Sask.

This lake, situated in townships 14 and 15, range 22, west of the 3rd meridian, occupies an undrained basin surrounded by morainic hills which rise in places some 50 feet above the normal level of the lake. There is a crystal bed of varying thickness, 30 feet of crystals being encountered in one of the drill holes. The crystal bed covers an area of approximately 325 acres with an average depth of 10 feet.

The following analyses* are of material from this deposit:—

	Hole No. 7	Hole No. 11	Hole No. 17
Insoluble	6·00%	6·00%	11·00%
Iron oxide and alumina	0·70	0·60	1·23
Calcium carbonate	....	....	2·76
Calcium sulphate	1·94	1·57	....
Magnesium carbonate	....	....	1·55
Magnesium sulphate	2·92	2·29	....
Sodium chloride	0·74	0·77	0·82
Sodium sulphate	86·51	87·71	82·08

*Analyses made on dried material.

This deposit is approximately 11 miles northwest of Tompkins, Sask., on the Canadian Pacific railway.

Chain Lake, Sask.

This is a long narrow lake situated in sections 10, 15, 16 and 21, tp. 18, range 20, west of the 3rd meridian. The surrounding country is comparatively flat-lying and the depression is correspondingly shallow. There is a crystal bed with an average depth of 2·25 feet.

The crystal bed covers approximately 70 acres.

An average analysis of the dried material from this lake is as follows:—

	Per cent
Insoluble	7·75
Iron oxide and alumina	2·00
Calcium carbonate	2·05
Calcium sulphate	3·00
Magnesium sulphate	4·48
Sodium sulphate	79·50

The deposit lies approximately 16 miles to the southwest of Cabri, Sask., a station of the Swift Current-Empress branch of the Canadian Pacific railway.

The water in another lake lying one-half mile to the south is strongly alkaline but no crystal bed was encountered in it.

Snakehole Lake, Sask.

This lake is situated on sections 11, 12, and 13, tp. 18, range 19, west of the 3rd meridian, and is 7 miles south of Cabri station on the Canadian Pacific railway. There is a large crystal bed in the bottom of this lake covering approximately 460 acres. A depth of 20 feet of crystals was encountered in one hole. Numerous springs feed into this lake. At the north end of the depression the banks rise almost vertically in places to a height of 100 feet above the lake level, the slopes of the surrounding hills being more gentle towards the southern end of the deposit. Scattered through the crystal bed are numerous mud holes varying from a few feet to many feet in diameter.

An average analysis of the dried material from this deposit is as follows:—

	Per cent
Insoluble	4·00
Iron oxide and alumina	0·55
Calcium sulphate	2·06
Magnesium sulphate	5·24
Sodium chloride	0·75
Sodium sulphate	87·44

Wiseton, Sask.

There are two lakes 21 miles south of Wiseton, Sask., situated in section 32, tp. 23, range 12, west of the 3rd meridian. These lakes cover approximately 270 acres but there was no crystal bed visible.

An average sample of the brine from these two lakes gave the following results in parts per million:—

Insoluble	20
Calcium sulphate	20
Magnesium sulphate	200,000
Sodium chloride	9,500
Sodium sulphate	80,000

Operating Deposits

Three deposits are being developed at the present time and plans are under way for the opening up of several others.

Salts and Chemicals, Ltd.

At Dana, Sask., a half-million dollar plant is nearing completion, to extract salt cake and other chemical products from the brines of Muskiki lake, formerly Houghton lake, 23 miles west of Humboldt, Sask. The

company operating this deposit is The Salts and Chemicals, Ltd., controlled by Canadian and United States interests. The refining plant of this company, which was formerly at Kitchener, Ont., is now being removed to the lake. When this plant is in operation it is estimated that the output will be 30,000 tons of salt cake per year, besides Epsom and other salts recovered as by-products. A small village has been established at the lake with housing accommodation for 60 men. When the plant is working at fuller capacity 100 men are to be employed.

Bishopric and Lent Co.

At Frederick lake, five miles southwest of Dunkirk, Sask., and 38 miles from Moose Jaw, Sask., another salt cake recovery plant has been erected by The Bishopric and Lent Co., with head offices at Cincinnati, Ohio. This plant is practically completed, and as soon as it proves commercially successful, further units are to be added to increase the output. At the present time 20 men are employed at this plant.

Soda Deposits, Ltd.

At a lake five miles north of Fusilier, Sask., an experimental plant has been operated by a company called Soda Deposits, Ltd., with head office at Calgary, Alta. This deposit, although somewhat smaller than some of the other deposits, contains sodium sulphate in a very pure state, and several shipments have already been made. This company hopes in the near future to be in a position to put its product regularly on the market.

MAGNESIUM SULPHATE AND SODIUM CARBONATE DEPOSITS

In British Columbia, several deposits of magnesium sulphate were visited, as well as a number of occurrences of sodium carbonate.

Spotted Lake, B.C.

This lake lies approximately one-half mile north of the southern entrance to Richter's pass. The nearest town to the deposit is Oroville, Washington, U.S.A., which is distant about 6 miles. It is 40 miles by road south of Penticton, B.C. The deposit occurs in a flat depression known as Spotted lake, which is a partially dried up lake containing alternate circles of saturated brine and dried silt.

A small shipment was made from this lake in 1915, and it has been worked intermittently since that time. Approximately 1,600 tons of crude magnesium sulphate were removed from this deposit up to 1920, when operations apparently were abandoned. This material was hauled by auto truck to the Oroville plant of the Stewart Calvert Company, for treatment, where the crude salts were dissolved and recrystallized for sale to the drug and tanning industries.

Basque Chemical Co.

The Basque Chemical Company is operating a series of five lakes situated fifteen miles west of Ashcroft, B.C. From these lakes they are excavating crude magnesium sulphate (Epsom salt), which is shipped to Vancouver, where it is refined and sold as medicinal salts and to the tanning industry. Plans are now under way for greatly extending the development of this deposit.

Clinton, B.C.

There is a small lake one mile south of the town of Clinton, B.C., from which a small tonnage of magnesium sulphate was obtained a few years ago. This deposit was not operated during 1922.

Lillooet Soda Company

In the vicinity of Meadow lake, fifty miles north of Clinton, B.C., the Lillooet Soda Company is operating a sodium carbonate lake and shipping the product to Vancouver over the Pacific Great Eastern railway. This material is being disposed of at the present time to the soap manufacturers of the Pacific coast, but plans are under way to dry the material at the lake and increase the output.

This company also owns several other lakes of the same material which they propose to operate at some future date.

INDUSTRIAL USES OF GLAUBER'S SALT AND EPSOM SALT

In the chemical manufacturies, Glauber's salt and Epsom salt find a very extensive application, and the demand for these products is ever increasing. Since by far the greater part of the Canadian consumption is imported, it is of importance to analyse their different uses with a view to finding whether material from Canadian deposits cannot be utilized.

Sodium sulphate is used extensively in the pulp and paper, glass, dye and textile industries, and to a smaller extent for medicinal and tanning purposes. Magnesium sulphate is employed for tanning and dyeing, and for textile and medicinal use.

Pulp and Paper Industry

The manufacturers of kraft paper are very large consumers of salt cake, using annually over 50,000 tons. The principle upon which this process depends is the solvent power of caustic alkali on the non-cellulose constituents in the wood. Consequently sodium sulphate cannot be used directly, but has to be converted into caustic alkali and dissolved in water. This solution is termed white liquor and is composed mainly of sodium hydrate and sodium sulphide. To prepare this white liquor, the so-called black liquor, containing the dissolved non-cellulose substances, obtained from the process, is evaporated to 35° Be and put through a rotary furnace. At the discharge end of this furnace, enough sodium sulphate is added to replace the alkali lost in the treatment of the wood. It is then shovelled into smelting furnaces where the sodium sulphate is reduced to sodium sulphide and carbonate. From the smelting furnace the melt flows in a molten condition to dissolving tanks containing water or dilute washings from the sludge in the causticizing room. When the solution has reached the desired density it is discharged into the causticizing system and lime is added. The reaction with the lime is as follows:—

$$Na_2CO_3 + CaO + H_2O = 2NaOH + CaCO_3.$$

Magnesium sulphate is used in the paper industry for weighting paper.

Glass Industry

Manufacturers of glass bottles and other containers use comparatively small amounts of sodium sulphate or salt cake (Na_2SO_4), according to some manufacturers only about 40 lbs. per ton. Since it gives a more homogeneous batch than when soda ash is used, a very clear glass is obtained, therefore it can be advantageously used in window glass and where very clear and white glass is required. The window glass manufacturers require about 6-10 per cent sodium sulphate (Na_2SO_4) but foreign manufacturers often add as high as 25 per cent to their batch.

Tanning Industry

Sodium sulphate is not used in the tanning industry proper, but comparatively large amounts are used advantageously in curing hides, superseding salt. It is difficult to arrive at a figure of the requirements for that purpose. However, large amounts of sodium sulphide are used mixed with lime, or by itself. In practice, sodium sulphide is always obtained by the reduction of sodium sulphate. The immersion of hides in a solution of sodium sulphide removes the hair quickly, freshens the grain, and imparts great toughness to the hide. A tannery using sodium sulphide will require as high as 75 tons per year for an output of 180,000 hides.

Magnesium sulphate is used by the tanneries in manufacturing sole leather, the estimated annual requirement for Canada being about 1,000 tons. It is used in sole leather only, to get a clean, shiny cut; it also helps to retain the moisture in leather and increases its weight.

Dye Industry

The present estimated annual consumption of Glauber's salt by the dye works is from 1,300 to 1,500 tons. The dyers prefer the natural Glauber's salt to manufactured salt cake as it is free from nitrates and nitrites which readily oxidize the dye. Magnesium chloride tends to disassociate the colours.

The effect of Glauber's salt under the general theory of dyeing is, mechanically retarding the interaction between the colour-acid and the fibre, chemically retarding the liberation of the colour-acid from the dye salt, and in affecting the solubility of the dye stuff solution.

The general effect of the addition of sodium sulphate appears to be a more uniform distribution of the dye, since this substance has a slight solvent action on the dye taken up by the fibre, thus removing it from those places in which the dye may have been deposited in excess and generally retarding the operation of dyeing, thus obtaining a slow and even setting.

Epsom salt is also used in the dyeing industry but not to a very large extent. In some cases it is used in the after treatment in order to increase the fastness to washing. Sodium sulphide is extensively employed for the sulphur dyes.

Medicinal Use

For medical purposes Glauber's salt is employed as an aperient and is one of the safest and most innocent known. It is to some extent used in cattle food and especially for veterinary uses. Also, it has been employed in cooling mixtures. Magnesium sulphate has an extensive use in medicine and very large quantities are used for this purpose, estimated at about 500 tons per annum.

Textile Industry

Magnesium sulphate is extensively used in textile manufacture for various purposes. In bleaching wool where sodium peroxide is used, since caustic alkali attacks the wool, magnesium sulphate is added to destroy its corrosive effect. It is also used for weighting textile fabrics, especially silk. Printed cotton is always "finished," the finishing material consisting of a mixture of kaolin, gypsum, etc., and magnesium sulphate. Magnesium sulphate mixed with gypsum and ammonium sulphate is used for the manufacture of non-inflammable fabrics.

III

VOLCANIC ASH NEAR WALDECK, SASK.

Location of Deposit

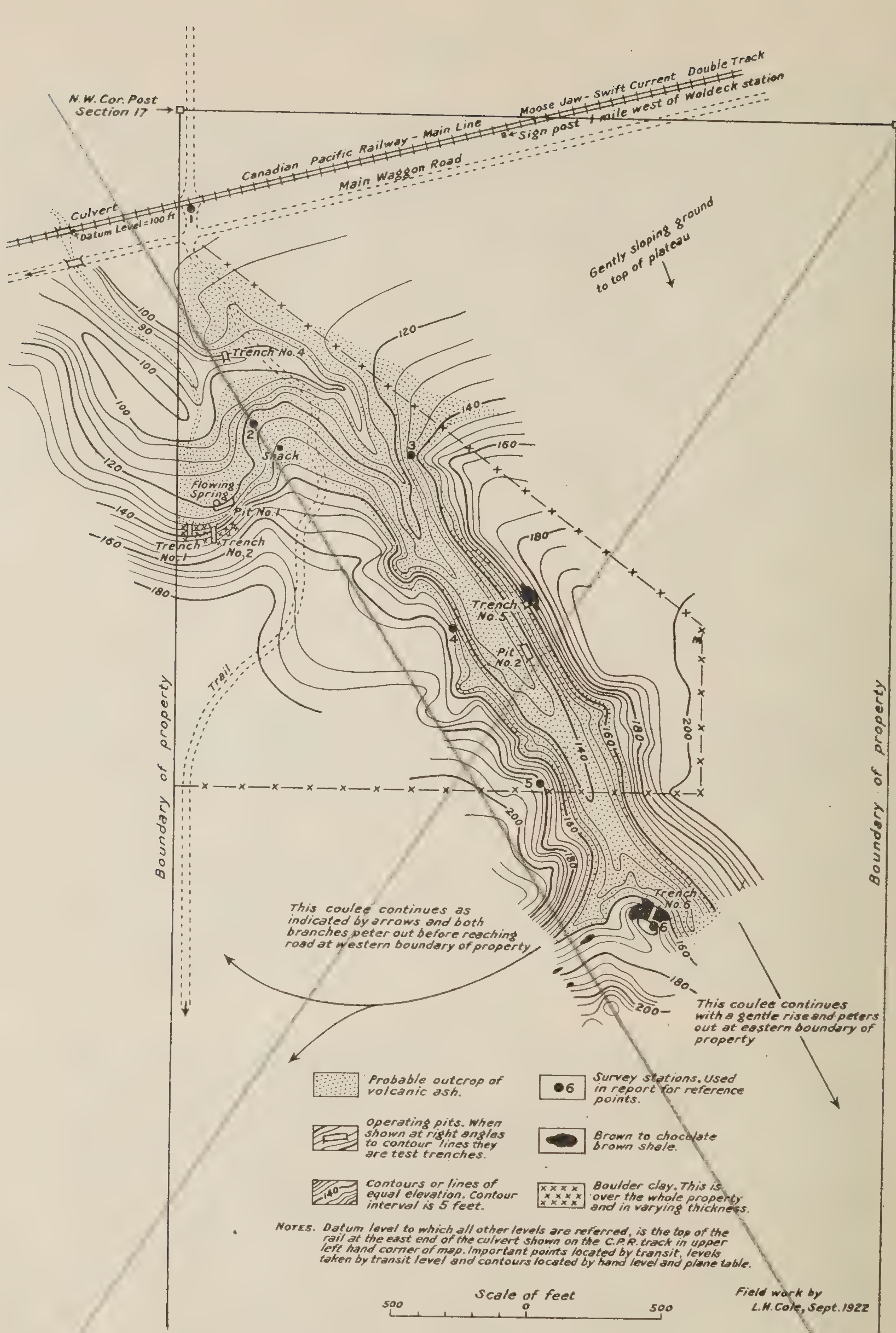
A deposit of volcanic ash underlies an extensive area in the district lying to the southwest of Waldeck, a station on the main line of the Canadian Pacific railway, 11 miles northeast of Swift Current, Sask. To have properly determined the exact extent of this material in this district would have taken considerable time; attention was therefore concentrated on that part of the deposit where the beds were already exposed and where a minimum amount of work would furnish the most information.

The examination was confined to the west half of section 17, township 16, range 12, west of the 3rd meridian, an area of 320 acres more or less. This part of the deposit is controlled and operated by the Van-Kel Chemical Company, Limited, with head office at Swift Current, Sask.

Topography

The railway follows the south side of what appears to be an old river channel that has been cut below the general level of the surrounding plain. The southern bank of this old river crosses the northwest corner of the property, so that the ground rises gradually as one goes south. There is a rise of 125 feet from the track level to the general level of the original plain, and since there are places on the property where the level is at least 10 feet below the level of the track, there is a maximum relief of 135 feet.

A coulee, some 500 feet wide, and running in a southeasterly direction, dissects the plain on this property. It joins the main valley at the northwestern corner of the half section and peters out at the southeastern boundary of the property 1,400 feet north of the southeast corner post. Approximately 3,000 feet southeast from the northwest corner post of the section another coulee branches off from the main coulee in a southwesterly direction and peters out near the western boundary.



Map of the property of the Van-Kel Chemical Co., Ltd
W½ Sec. 17, Tp. 16, Range 12, west of the 3rd meridian
Saskatchewan

FIG.

VI

SODIUM AND MAGNESIUM SALTS OF WESTERN CANADA

1923

L. Heber Cole

The investigation of the sodium sulphate deposits of western Canada, commenced during the season of 1921, was continued during the season of 1923. A second drill was employed and two parties operated in the field. The two drilling parties were in charge of Messrs. H. A. Leverin and M. F. Goudge, while the writer had general supervision over the whole work, as well as carrying on preliminary examinations on a number of deposits not so far examined.

Owing to numerous delays the second drill was not delivered at Swift Current, Sask., until the middle of July, and in consequence the detailed examination of the deposits was late in starting.

From June 15 to July 15 the two parties were engaged with the first drill in putting down a hole and surveying and otherwise testing the deposit of volcanic ash described in the Summary Report of the Mines Branch for 1922[1].

On the arrival of the second drill the two parties were immediately formed, the one under Mr. Goudge commencing work on the deposits near Ingebright, Sask., while the other under Mr. Leverin proceeded to the deposit 11 miles south of Regina Beach, Sask.

Six deposits were examined in detail, one party remaining in the field till the first week in November, while the second party operated till the end of November.

INGEBRIGHT DEPOSITS

Townships 16 and 17, range 25, west of the 3rd meridian, are in what is known as the Ingebright district of Saskatchewan. The sulphate deposits in these townships are strung out in a line north and south. These deposits are eight in number and vary in extent from one of the largest crystal bodies yet discovered down to the so-called 'alkali slough', in which sodium sulphate is only formed when the brine evaporates in the late summer and leaves a white crust of sodium sulphate 1 to 4 inches thick on top of the mud over the whole surface of the slough. These deposits are all long and relatively narrow, occupying depressions in the bed of a well defined valley which can be traced for many miles. Two of these deposits were examined in detail during the season.

[1]See Mines Branch Report No. 605, pp. 15-20.

Deposit No. 1

This deposit occupies parts of sections 13 and 14, 23 and 24, 25 and 26 of township 16, range 25, west of the 3rd meridian. It is in a remote position as regards railway shipping facilities. The town of Maple Creek, on the main line of the Canadian Pacific railway, 38 miles to the southward, is the nearest shipping point, while to the northward the railway is slightly more distant. The roads in this district are of ordinary graded dirt, and at times, especially in the spring, are not in the best of condition for heavy traffic. It is quite possible that in the near future railway facilities will be available within a few miles, and if so, it will be an easy matter to run a siding to the deposit.

The deposit occupies a crescent-shaped basin over 700 acres in area. The level of the crystal bed is about 70 feet below the general level of the country, the banks of the basin rising sharply around the major part of the deposit from 40 to 50 feet above the crystal bed and then sloping gradually up to the general level of the prairie. There is an extensive crystal bed, averaging 22 feet thick, covering the bottom of this basin. One peculiar feature of this deposit was the discovery of two deep areas in the crystal bed. The deep area in the northern part showed a depth of approximately 140 feet of crystals, while the drilling in the southern part penetrated 120 feet of crystals without reaching the bottom of the bed. The deposit is by far the largest so far examined, a tonnage of approximately 25,000,000 tons of combined hydrous salts having been proved.

This deposit was examined and drilled during the field season of 1923, 36 holes being put down. The core from each hole was carefully sampled every 5 feet in depth and a composite sample taken representative of the material from the complete hole. The analyses of four of the composite samples from this deposit are given below and convey an idea of the composition of the material in this deposit.[1]

		Hole 1	Hole 7	Hole 16	Hole 27
	Per cent				
Insoluble	"	6·07	9·35	13·33	6·13
$NaHCO_3$	"	....	1·01	0·52	0·76
$CaSO_4$	"	1·02	5·37	7·60	5·92
$MgSO_4$	"	1·20	7·30	2·95	2·60
NaCl	"	1·09	1·73	1·86	0·59
Na_2SO_4	"	84·00	73·00	71·00	82·50
Total	"	93·38	97·76	97·26	98·50

The deposit is under lease to parties in western Canada, and it is hoped that a move will shortly be made to operate this property.

[1]At the time of writing the analyses of the 5-foot samples had not been completed, and while there are many variations in composition at certain depths, the composite samples above give an approximate idea of the general composition of the deposit.

Deposit No. 2

About five miles to the northwest of deposit No. 1 another deposit was drilled and sampled. This deposit is situated in sections 4 and 9, township 17, range 25, west of the 3rd meridian. The nearest shipping point on the railway is Prelate, Sask., 35 miles to the north on the Empress branch of the Canadian Pacific railway.

This is one of the larger of the series of alkali deposits that occur in the Ingebright district and occupies the bed of a valley that enters the southwest end of deposit No. 1, previously described. The deposit is about 8,000 feet long, north and south, and 1,500 feet wide at its widest part.

The banks of the southern part of the lake have very gentle slopes. The soil is sandy and almost free from boulders. In the northern portion, however, the banks are steep, rising sharply to a height of from 40 to 50 feet, and stony boulder clay is predominant, especially on the eastern shore.

There are four springs along the margin of the lake, two on the west side and two on the east side. These springs are more in the nature of seepages than true springs, as they each cover a considerable area and the actual flow of water is small. There was only one small spring observed welling up through the crystal bed.

The crystal bed extends to within 50 feet of the shore, except in the northern and southern extremities of the lake where the crystal does not extend into the narrow coves. The crystal is covered with a layer of mud varying in thickness from 10 inches to over 2 feet. On the surface of this mud there is deposited in the autumn a thin layer, one inch in thickness, of pure crystal. This layer readily dissolves in wet weather.

Twelve drill holes were put down in this lake and the holes showed that the bed of the lake is very uneven. The depth of the crystal in the middle of the southern part of the deposit varies from 7 to 25 feet, while in the northern part, with the exception of one deep area, the average depth was not more than 4 feet.

In the deep area in the northern part of this deposit, a depth of 80 feet of solid crystal was encountered. The quantity proved was approximately 2,800,000 tons of hydrous salts.

The crystal bed is comparatively free from both included mud and mud strata, the crystal being clear and hard from top to bottom. Underlying most of the southern part of the crystal bed is a soft calcareous ooze through which the drill rods sink of their own weight until a hard compact stratum is reached.

Analyses of three composite samples from this deposit are given below:[1]

		Hole 1	Hole 4	Hole 7
Insoluble	Per cent	2·70	11·20	2·33
$NaHCO_3$	"	0·94	0·79	0·63
$CaSO_4$	"	0·76	2·15	0·70
$MgSO_4$	"	1·10	0·54	1·85
$NaCl$	"	0·32	None	0·16
Na_2SO_4	"	94·20	84·71	93·90
Total	"	100·12	99·39	99·57

[1]See previous footnote on page 48.

HORIZON DEPOSIT

This deposit, known locally as Horseshoe lake, is situated on sections 7, 8, 16, 17, 20, 21, township 9, range 25, west of the 2nd meridian. The nearest shipping point is 16 miles south, at Viceroy, Sask., a station on the Forward branch of the Canadian Pacific railway.

The crystal bed covers practically the whole lake basin and in general runs close to the shore. In the southern end of the lake, between the shore and the island, the bed is solid with no mud holes, the depth averaging about 15 feet. In the northern part of the deposit the crystal bed is more broken up and patchy.

The crystal encountered in the drill holes was very pure and free from mud and other foreign matter, being of a bluish colour and very firm. The thickness of the mud covering the crystal on the south end of the lake rarely exceeds 6 inches, but becomes deeper in the north end, especially near the islands, where it often reaches to a depth of 3 feet.

Saline water, in the early part of the summer, covered the deposit to a depth of about 8 inches, but during the latter part of the summer and early fall the intermittent crystal bed soon formed.

Analyses of composite samples taken from this deposit are given below:[1]

Horseshoe Lake

		Hole 1	Hole 3	Hole 5	Hole 6
Insoluble	Per cent	5·50	3·76	2·03	4·10
$NaHCO_3$	"	....	....	1·18	1·19
$CaSO_4$	"	0·34	0·61	0·61	0·85
$MgSO_4$	"	1·09	1·06	1·65	1·40
$NaCl$	"	1·53	2·14	0·62	0·56
Na_2SO_4	"	89·00	90·00	93·00	91·70
Total	"	97·46	97·57	99·09	99·80

REGINA BEACH DEPOSIT No. 1

This deposit is situated in a depression at the northeast corner of section 25, township 20, range 22, west of the 2nd meridian. The nearest point on a railway is Regina Beach, a station on the Canadian National railways, 11 miles distant.

The lake is nearly rectangular, about 1,600 feet in length and its greatest width is 600 feet. Notwithstanding its small size, compared with many other similar deposits in Saskatchewan, this deposit was one of the earliest to be operated, and shipments of natural Glauber's salt have been made from it annually for a number of years.

The crystal bed is irregular and intersected with a chain of large mud-holes, so that the crystal bed covers less than a quarter of the whole lake area. Mud covers the crystal bed, ranging in thickness from six inches to one foot. Saline water varying in depth from 3 feet to 3 feet 8 inches covered the whole deposit when examined in the month of July, 1923.

[1]See previous footnote on page 48.

The lake seldom dries up, but at a lower temperature, the Glauber's salt crystallizes in large quantities and sinks to the bottom, when it is harvested. This operation is performed entirely by manual labour, the men standing in the brine and shovelling the precipitated crystals on to scows from which they are unloaded on a wharf. After draining, the salts are bagged and shipped by wagon to Regina Beach station.

Four holes were sunk in the crystal bed; No. 1 in the south end with 10 feet of crystals; No. 2 in the centre with 9 feet 6 inches of crystals; No. 3 in the north end of the bed with a crystal depth of 12 feet 6 inches; and No. 4 in the west end of the bed with a depth of 5 feet 6 inches of crystals. The estimated tonnage of crystal in the permanent bed is approximately 50,000 tons.

The crystal in the permanent bed is of a bluish white colour, clear and hard and comparatively free from foreign substances.

Analyses of material from this deposit are:—

		Hole 1 5′–10′	Hole 2 0–5′	Hole 3 10′–12½′	Hole 4 0–5½′
Insoluble	Per cent	5·03	5·70	5·17	6·00
$NaCl$	"	0·29	0·07	1·50	0·20
$NaHCO_3$	"	1·62	0·89	0·92	1·51
$Al_2O_3Fe_2O_3$	"	0·73	–	–	–
$CaSO_4$	"	3·40	3·00	4·08	1·87
$MgSO_4$	"	2·20	2·15	1·50	2·13
Na_2SO_4	"	83·80	88·80	86·80	85·80
Total	"	97·07	100·61	98·47	97·51

This deposit is controlled by a company called The Regina Oil and Chemical Co., Ltd.

REGINA BEACH DEPOSIT No. 2

An alkali lake situated in section 21, township 20, range 22, west of the 2nd meridian, was reported to contain a crystal bed of considerable area and depth. Detailed examination, however, revealed only a narrow strip of crystal bed about 2,000 feet in length and 100 feet wide, following the east shore, and two smaller beds, one on the west shore, opposite the south end of the main bed, the other between the two beds. The crystal beds are covered with 3 feet of mud, and the depth of brine was about 2 feet when the deposit was examined in August, 1923. The crystal beds above mentioned are free from mud holes as far as could be ascertained. There was no possibility of getting the drill on the deposit on account of the treacherous nature of the mud bottom, so that no drilling was done, but sufficient bar tests were made to delimit the permanent crystal beds. The depth could not be obtained owing to the heavy covering of mud. The harvest crystal bed which forms in the fall could be readily gathered as the north end of the lake is close to the road, but so far practically no development work has been done by the owners.

SALT LAKE DEPOSIT

A chain of four lakes, joined by narrow channels, and carrying sodium salts in solution and in crystal form, is situated in sections 1, 12, 13, 24, township 4, range 21, west of the 2nd meridian. The nearest railway shipping point is at Hardy, a station on the Bengough branch of the Canadian National railways, situated 14 miles to the north of the lakes.

The three southern lakes all contain crystal beds covering their total areas, and coming close to the shore.

Twelve holes were drilled in the two southern lakes and crystal depths varying from 2 feet to 8 feet 6 inches were encountered. The third lake was tested with a bar and showed depths of from 3 to 4 feet, including the intermittent crystal. The northern lake contained no permanent bed.

The intermittent crystal bed averaged 12 inches in depth. Harvesting and shipping of the intermittent crystal has been carried on in a small way each fall for a number of years, and a very pure crystal is obtained from this top bed, since there is very little mud on top of the permanent bed. The permanent bed, however, carries considerable mud inclusions.

The following analyses are of samples taken from this deposit:—

		Hole 2	Hole 11	Surface crystal
Insol.	Per cent	15·87	12·93	0·15
NaCl	"	....	trace	trace
$NaHCO_3$	"	0·68	0·68	trace
$Al_2(SO_4)_3$	"	1·00	2·08	trace
$CaSO_4$	"	0·94	0·70	trace
$MgSO_4$	"	0·84	1·85	1·25
Na_2SO_4	"	77·97	79·18	98·30
Total	"	97·30	97·42	99·65

Summary and Conclusions

The production of sodium sulphate from the natural deposits of western Canada is still in its infancy. There is a fairly steady market for this material in the anhydrous form, in the pulp and paper industry, but the main consuming centres are in eastern Canada, and the present high freight rates from the deposits to the markets are an important factor. Very little of the crude material, as such, can be marketed, and this necessitates the installation of refining plants. The product has to compete against that produced as a by-product from acid manufacture, but there are hopes that simple refining methods and lower freight rates will eventually help this industry.

The resources of sodium and magnesium sulphate of western Canada are among the very few resources of which estimates of reserve material can be obtained with any degree of accuracy. The deposits of these materials are confined to well-defined areas and it is only a matter of investigation to determine the tonnages.

While the work carried on by the Mines Branch on these deposits in western Canada cannot be expected to cover in detail all of the already known deposits, it has proved, in the twelve lakes so far drilled, the presence of hydrous sodium and magnesium salts, mainly sodium sulphate, to the extent of fifty million tons (50,000,000). Private reports by engineers and chemists on other deposits not so far examined by the Mines Branch in detail, give estimated tonnages of another twenty million (20,000,000). It can be readily seen that, although it may be a number of years before these deposits are being worked to their fullest extent, Canada has in such deposits a resource of great potential value.

VII

CURRENT ACTIVITIES IN ZINC-LEAD MINING IN BRITISH COLUMBIA

A. H. A. Robinson

The following observations on conditions prevailing in the silver-lead-zinc mining industry in the Skeena and Kootenay districts of British Columbia were made during the course of a visit to the chief mining centres in these districts, in September and October, 1923. Some remarks on the copper situation in the same localities have been added.

SKEENA DISTRICT

Omineca Mining Division

For a number of years, beginning with 1913, there was a fairly steady and at times considerable output of silver-lead and silver-zinc ore, and, later, concentrates from the vicinity of Hazelton, chiefly from the Silver Standard mine, but this production has now ceased entirely.

The Silver Standard is situated on the northwest side of Glen mountain, about six miles by road from New Hazelton station on the Canadian National railways, the shipping point for the ore. The first shipments, consisting of silver, lead, and zinc ores, were made in 1913. In the spring of 1918, an ordinary wet concentrating mill was built, and from that time until operations practically ceased, in the fall of 1920 (it was worked for three months in 1922) the output consisted of silver-lead concentrates and silver-zinc concentrates. The mill, in which the concentrating was done on jigs and tables, has a rated capacity of 50 tons of ore per 24 hours, and is situated about two miles from the mine, from which the ore was conveyed to the mill in motor trucks. Mill water was obtained from Twomile creek, and also sufficient power to run the tables and the dynamo for a small electric plant; the other necessary power was supplied by a steam plant using wood for fuel.

There are nine known veins on the property, but only two have been important producers, and the bulk of the production has been obtained from one only, the main vein. The ore was at first won by shaft entry, later by cross-cut tunnels.

As indicative of the grade of ore obtained, it may be said that from the time the mine commenced to ship, in 1913, up to June 1917, there had been shipped 2,229 tons of ore, carrying 746,259 pounds of lead, 516·8 ounces of gold, 304,411 ounces of silver, and about 20·3% of zinc. In 1919, from 3,000 tons of ore treated in the mill there was obtained 128 tons of silver-lead concentrates carrying about 35% lead and 225 oz. of silver to the